Effects of Grass Seeding on Post-Fire Erosion in a Sierra Nevada Pine-Hardwood Community

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Introduction

The Pilot Fire of August 1999 burned 4,000 acres on the Stanislaus National Forest. The Burn Area Emergency Response (BAER) team determined that there was a threat to soil productivity on 160 acres of forested site. The amount of high burn severity and soil loss were thought to be outside of what would naturally occur in this ecosystem.

Seeding was discussed as a possible BAER treatment to reduce soil erosion. The need for seeding was debated and controversial among BAER team members. We chose not to seed. Instead we monitored the area by designing a study to determine if seeded grasses in test plots increase plant cover and reduce post-fire soil loss.

Two seed mixes were tested and compared to non-seeded controls. Plant cover, species composition, and soil loss were monitored for two years on 29 plots. The study was authorized as one of the BAER activities approved for the Pilot Fire.

Monitoring Area

The monitoring area is located in the upper part of the burned watershed at elevations of 4,000 to 4,200 feet (Figure 1). In general, the landscape or Ecological Unit is a pine-hardwood community. Average annual precipitation is 40 inches. The north aspects consist of ponderosa pine and interior live oak, with a bear clover understory. South aspects tend to be a montane chaparral type, dominated by white leaf manzanita with a bear clover understory. Scattered ponderosa pine and gray pine also occur on south facing slopes. Chaparral dominates the landscape below 4,000 foot elevation. The area represents a transition between forested and non-forested plant communities, where fire is assumed to play an active role in dynamically shaping the pattern and composition of vegetation.

Soils are classified as Holland family, developed from granitic parent material. The monitoring area has a generally southwest aspect and may represent a warm mesic soil temperature regime as it transitions from chaparral to the pine and mixed oak communities. This portion of the burn was mapped as having a high burn severity with a high potential for soil loss. Hydrophobic soils were of limited extent. Soil compaction was noted as a condition associated with terraced areas where site preparation and reforestation efforts followed a wildfire in the 1940's. A project vicinity map is provided in Appendix A that shows the location of the monitoring area and the monitoring sites.

Figure 1. Landscape view of the monitoring area.

Methods

The monitoring area was stratified by vegetation type, soil type, slope gradient, and past disturbance. Areas with a pine-hardwood and montane chaparral plant community, Holland family soils, and slopes between 25 and 50 percent with a high burn severity were candidate areas for establishing plots. Disturbed areas such as terraced slopes, skidtrails, and slopes that were contour subsoiled as a BAER treatment were avoided. Shallow soils with a shrub and oak community were avoided.

We found 12 sites that met the above criteria. At each site 2 or 3 plots were located depending on available space. Each plot consisted of a silt fence and a watershed about 20 feet by 100 feet (Figure 2). Plots were required to have a uniform ground surface (no stump holes, rock outcrop, gullies) and a definable watershed boundary (ridge, road, ditch). Controls and treatments were assigned randomly at each site. Twenty-nine plots were installed with a minimum of 7 replications per treatment. Robichaud and Brown (2002) report that most erosion scientists use 5 to 7 replications for silt fence erosion plot studies.

Figure 2. An insloped road defines the watershed for 3 plots. Vegetation is Ponderosa pine – Black oak – Bear clover.

Two treatments were tested. The Barley treatment consisted of *Hordium murinum* and *Elymus glaucus* . The application rate per acre was 95 pounds of barley (30 seeds per square foot) and 8 pounds of blue wild rye (25 seeds per square foot). The *Elymus glaucus* originated locally from the Stanislaus Forest. BAER policy states that "to the

extent practicable, seeds used in erosion control and fire rehabilitation shall originate from genetically local sources of native plants" (USDA 1998).

The native treatment was seeded at the rate of 14 pounds per acre, as recommended by the supplier (135 seeds per square foot). The native mix consisted of 2 pounds of Deschampsia elongata, 5 pounds of *Elymus glaucus*, 5 pounds of *Bromus carinatus*, and two pounds of *Vulpia microstachys*. Seed was applied with a "belly grinder" in late October. Controls were unseeded and normal vegetation recovery was allowed to occur.

Soil Loss

Soil loss was recorded for two years. In May of 2000 and 2001, sediment caught in the silt fence was sampled for depth at 10 randomly located points within the trap. Depths were sampled by plunging a soil spade into the sediment to a point where it hit the excavated bottom of the sediment trap (Figure 3). Contact with the floor of the trap was easily detected.

Sediment depths were converted to tons per acre based on the average depth, length, and width of sediment in the trap, soil bulk density, and the watershed area of each plot. The Stanislaus Forest Soil Survey provided bulk density data. (USDA 1995).

Figure 3. Sediment sampling using a tape and spade

Vegetation Response

Each plot was stratified into 20-foot segments along the length to insure that samples were distributed along the slope, and a tape was laid down the center of the plot. Within each 20 foot segment a random number between 1 and 20 was selected from a random number table to determine a point from which to go left or right of the center tape. A coin was tossed to determine whether a sample was to come from the right or left of the centerline, and a random distance from the centerline but still within the plot was selected. In this way 5 samples would be drawn from each plot. A "Daubenmire frame" (National Applied Resource Sciences Center 1996) was placed at each sample point and cover was estimated within the frame.

Over a two year period, each plot was visited twice during the year. The first cover sample was taken in February to assess an average first winter ground cover. November through March is the typical wet season. The second sample was taken in the spring to assess a full season of growth.

During each midwinter visit, cover by lifeform designated as grass, forb, shrub, and tree was recorded for each sample. Other attributes such as bare soil, gravel, cobble, rock, and charcoal pieces larger than 0.5 inch were recorded as well. In the spring, these same variables were recorded, and in addition, the cover by species was noted

Analysis

A one-way analysis of variance was used to test the differences between treatments and controls for each of the two years of the study. Soil loss in tons per acre was compared by treatment by year. Vegetation cover as well as cover from other materials (rocks, gravel, and litter for example) was compared by treatment and time of year (mid-winter and spring) for each of the two years. The Levene's, Welch, and Brown-Forsythe tests were used to account for non-equal variances in the data. The significance level was set at 5 %.

Although an attempt was made to locate sites away from man-made features, 3 of the plots incurred substantial sediment from roads and old terraces. Two plots were constructed below a native surface road that was subsequently graded to an outslope with fresh material pushed onto the fillslopes. The amount of rilling and soil loss on these plots was directly affected by runoff from the road. A third plot was affected by runoff and rilling that started on terraced ground and continued downslope onto the plot. These were designated as disturbed plots and analyzed as a separate group for sediment yield.

Prior to the burn, whiteleaf manzanita communities dominated south aspects and ponderosa pine-interior live oak communities dominated north aspects. After the fire, there also appeared to be a substantial difference in early vegetation response on the two aspects. Therefore, a separate analysis of variance compared soil loss and vegetation response by aspect. Aspects were grouped between 90 and 269 degrees to represent south and 270 to 89 degrees for north.

Results

Soil Loss

Table 1 shows soil loss results. There was no significant difference between the control and either treatment or between the barley and native treatment, for either year 1 or year 2. Very little erosion occurred in year 2 on any treatment. The negative 0.3 tons/acre value suggests that more than 10 random sample points may be required for accuracy of measurement.

There was a significant difference in soil loss between disturbed sites and all other sites at the end of the first year.

Table 1: Soil loss by treatment (29 plots)

Mean Soil Loss (tons/acre)				
Date Sampled	**Control**	**Barley**	**Native**	**Disturbed**
5/00	9.7	9.7	7.2	26.1
5/01	- 0.3	0.3	0.4	0.1

Vegetation Response

Table 2 shows the development of cover through time for each treatment. Bare slopes dominated the study area immediately after the fire and into midwinter of the first year. By midwinter total vegetation cover (shrubs, forbs, and grasses) was less than one percent for each treatment. Other materials such as rocks, cobbles, charcoal pieces, and litter provided about 6 percent additional cover, leaving an average of 93 percent bare ground. Cover values may cumulatively be greater than 100 percent, for example, a taller shrub layer may overlap vertically with a shorter grass or forb layer.

By spring of the first year, total vegetative cover was 24, 20, and 18 percent respectively for the control, the barley, and the native treatment. Bare ground averaged about 70 percent. Total vegetation cover and bare ground were not significantly different among the treatments or control. The majority of the plants providing cover on all treatments at this time were non-seeded native species. Appendix B provides detailed information on percent cover and constancy by species.

Table 2: Development of cover through time.

Vegetative Cover by Treatment (%)					
Treatment	Cover Class	Date Sampled			
		2/00	5/00	2/01	5/01
Control	Grass	trace	1[1]	1[1]	2[1]
	Shrubs/Forbs	trace	23	35	58
	Litter	3	2	14	29
	Bare	92	70	52	27
Barley	Grass	trace	5	8[1]	12[1]
	Shrubs/Forbs	trace	15	27	41
	Litter	2	3	18	33
	Bare	94	72	48	35[1]
Native	Grass	trace	7	16[1]	24[1]
	Shrubs/Forbs	trace	11	27	32[1]
	Litter	3	4	37[1]	52
	Bare	92	73	29[1]	18

[1] Represent variables with significant differences.

By midwinter of the second year, total vegetation cover was 36, 35, and 43 percent respectively for the control, barley, and native treatments. Total vegetation cover was not significantly different among treatments or control. However, the combination of vegetation cover (shrubs, forbs, and grasses) plus litter provided higher overall cover on the native seeded plots. Bare ground was significantly lower on the native treatment. Bare ground averaged 29 percent on native seeded plots and about 50 percent on the control and barley plots. Barley was non-persistent and provided sparse cover the second year.

By spring of the second year, total vegetation cover averaged 61 percent across all treatments and bare ground averaged 27 percent. The final readings showed many fine scale differences in the vegetation cover. Cover from tree species showing primarily as sprouts from the oaks became an important element for the first time in the study. Total shrub cover was highest on the controls, and it was significantly higher than on the native seeded plots. Total forb cover was also highest on the controls, and again, this cover was significantly higher than on the native seeded plots. Total grass cover was significantly lower on the controls compared to both the barley and native mix plots. The barley plots

also contained significantly more grass cover than the controls, but significantly less than the native mix. Total vegetation showed no significant differences, but bare ground was significantly higher on the barley plots than either the control or native plots. Again, the dominance of litter on the native plots showed significantly higher levels compared to the control or barley plots. By the end of the two years bare ground had been reduced from an overall average of 93 to 27 percent for all plots.

Vegetation Response by Aspect

Since different plant communities occupied different aspects prior to the burn, it was also expected that vegetation development would be different on these different aspects. This was confirmed. In general, plants established and provided cover much more rapidly on north aspects than south aspects, and this difference was maintained throughout the study. Bear clover was the dominant species on both aspects. It simply occurred in lower abundance on south aspects. Appendix C gives further detail.

Discussion

Soil Loss

BAER treatments, including seeding are expected to be effective. However, there is much debate on the issue of seeding as an effective practice. Griffith (1999) noted that the pros and cons of seeding are often discussed and field practitioners have questioned the practice. Taskey et al (1989) found that seeding with Italian annual ryegrass (*Lolium multiflorum*) resulted in higher post-fire erosion rates compared to unseeded plots. Taskey makes the point that the success of seeding efforts are judged more often by the amount of grass established than by the amount of actual erosion controlled or flood damage prevented. Thus, success is based more on assumed effectiveness than on measured effectiveness. Good studies are needed to support this on-going debate.

Other studies have evaluated the effectiveness of seeding after fire. Orr (1970) found that 30 percent cover reduced erosion by about half compared to bare ground and soil loss drops to negligible amounts when ground cover exceeds 60 percent. Robichaud et al (2001) tabulated results from published studies to determine probabilities of seeding "success". Seeding decreased erosion in only one out of eight first year studies. In the second year after fire, 78 percent of seeded plots and 67 percent of unseeded plots achieved at least 30 percent ground cover. More than half (56 percent) of all seeded sites were essentially stabilized (at least 60 percent cover), compared with only 17 percent of unseeded sites. Although effectively seeded slopes were three times more likely to be stable after two years than were unseeded slopes, the probability of achieving effective coverage is only 56 percent. Nevertheless they felt that seeding remains the only method available to treat large areas at a reasonably low cost per acre.

This study shows that seeding was not effective in reducing post-burn soil loss in a low elevation conifer-hardwood stand of the central Sierras, given an average precipitation year. Soil loss in plots seeded with the barley/blue wild rye mix and the native species mix did not vary significantly over a two-year period. Nor did soil loss differ significantly between seeded and unseeded plots. There was a difference in vegetative response on north and south aspects, however this was not reflected in different erosion rates.

The first year, plots eroded at similar rates (7 to 10 tons per acre) with the exception of the "disturbed" plots. Winter cover was less than one percent for both treatments and control. Obviously this is not sufficient to provide erosion control through the wet season. By midwinter of the second year, bare ground was reduced to 29 percent on the native plots and about 50 percent on the barley and control plots. Soil loss in the second year was minor. Orr's work showed a similar linkage between effective cover and soil loss. Plants provided adequate erosion control cover on controls and seeded plots through the second year.

Based on values obtained from the control plots, a background level of soil loss from sites at similar elevations with similar topography, soil type, and burn severity is expected to be around 10 tons per acre during the first year with negligible amounts thereafter. Rainfall can be a significant variable affecting erosion rates. Monitoring occurred during two average rainfall years absent of intense storms. Another caveat is results of this study may not be assumed to be applicable to locations outside of the Ecological Unit described for the monitoring area.

Soil loss, however was much higher on some areas of the landscape. Erosion was nearly 3 times greater on "disturbed" plots (plots receiving runoff from disturbed sites) compared to all other plots (table 1). "Disturbed" plots were immediately downslope from an old terraced plantation and a graded road surface where soil compaction influenced runoff patterns. Although of less concern in a large landscape, erosion or runoff that originates in previously disturbed areas or from facilities such as roads can contribute substantial sediment into small drainages. "Disturbed site" sediment sources may be considered by some as "point" sources because they originated from rills in a few short segments of roads or terraces, and it is difficult to apply these disturbed site values broadly across the landscape. Do these disturbed sites qualify as an emergency? Each BAER team looks at the values at risk and determines this on a case-by-case basis.

One of the BAER objectives is to control surface runoff to the extent feasible. BAER teams may pay particular attention to areas where soil compaction can increase runoff in burned watersheds. Treatments such as subsoiling on the contour and straw mulching can improve infiltration. Shredding burned trees may also be effective on some sites.

In regard to seeding, BAER teams will continue to debate the effectiveness of seeding as a burn rehabilitation treatment. Can seeding technology and first year results be improved? Superior results may be achieved by using engineered coatings. Coatings are relatively inexpensive compared to the cost of the seed. Some companies will prepare seeds by coating, pelleting, and priming that will alter germination and establishment characteristics (Becker 2001). This may be a topic for further technical development and testing in the wildland environment.

Vegetation Response

Seeded grasses did not hasten vegetation recovery. Immediately after the fire, slopes were essentially bare. This condition persisted until midwinter of the first year. At these elevations in the Sierra Nevada, such a response is not unexpected. During the fall and after the summer drought there is simply not enough time for soils to moisten, seeds to germinate, and plants to develop enough to provide significant cover. This, of course, is also the period when winter rains begin and major storms can deposit substantial amounts of precipitation in a short period. It was not until the first spring that vegetation cover began to cover sites. By the end of the first winter, Bear clover from pre-existing rhizomes, and annual forbs dominated the cover of all sites, but overall cover was less than 25 percent. Seeded grasses contributed little to first year cover.

During the second year plant cover continued to develop, and by the end of the study, shrubs, primarily bear clover, were clearly most abundant. By this time, overall vegetation cover was over 60 percent. Only in the native mix plots did seeded grasses form a substantial portion of the species composition. In this regard, if the decision is made to seed slopes on similar sites, it would appear that a native mix would provide far better cover than a non-native mix such as the commercial barley used here. Unanswered, of course, is whether shrubs and annual forbs would have provided as much cover as the seeded species had these native mix plots not been seeded. Results from the other treatments indicate this may be the case.

Interestingly, whiteleaf manzanita showed limited recovery during the study. This species was a pre-burn dominant on many of the south facing slopes. It is commonly thought of as a rapid occupier of lands after fire, and yet seedling occurrence and cover were low for two years after the burn. It seems unlikely that seed coats were not scarified through the heat of the fire, or that there were insufficient seed in the soil to allow rapid recovery of this species. It may be that the duration of the study was not long enough to record development of this species.

An important component of post fire vegetation cover is litter. It is highly correlated with the development of live vegetation on recently burned sites. Thus, litter generally did not begin to contribute significant cover until the beginning of the second winter. By this time, both treatment and aspect influenced litter

production. Plots seeded with the native grass mix had substantially higher levels of litter compared to other treatments. North aspects had more than twice the amount of litter as south aspects. Litter type was not differentiated. Thus, whether the seeded grasses made up a significant amount of the litter on native mix plots remains undetermined.

Conclusions

The question asked in this study was, "Will seeded grasses increase plant cover and reduce post-fire erosion in a pine-hardwood community of the central Sierra Nevada Mountains?"

Results of this study showed that seeded grasses did not increase initial plant cover or substantially reduce soil loss. Monitoring occurred during two consecutive average rainfall years without intense storms.

On all treatments a clear pattern of vegetation development occurred. Bare slopes were dominant immediately after the fire and into midwinter. Plant cover increased slowly throughout the spring, and first year vegetation cover culminated at about 20 percent. Sites were still dominated by bare ground. Vegetation continued to increase into midwinter of the second year when cover averaged around 40 percent. Even by this time, however, bare ground still occupied about one third to one half of the surface. By spring of the second year vegetation covered around 60 percent of the surface, and for the first time bare ground no longer dominated sites.

On all treatments plants provided only one percent cover through most of the wet season following the fire. With so little cover provided, all plots eroded at similar rates. In contrast, second year plant cover provided adequate erosion control cover on both seeded and unseeded plots. Litter appeared to be an important erosion control cover factor the second year.

The "disturbed sites" eroded much more significantly than other sites. Erosion from roads and old terraced plantations was notably more prominent.

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Appendix A

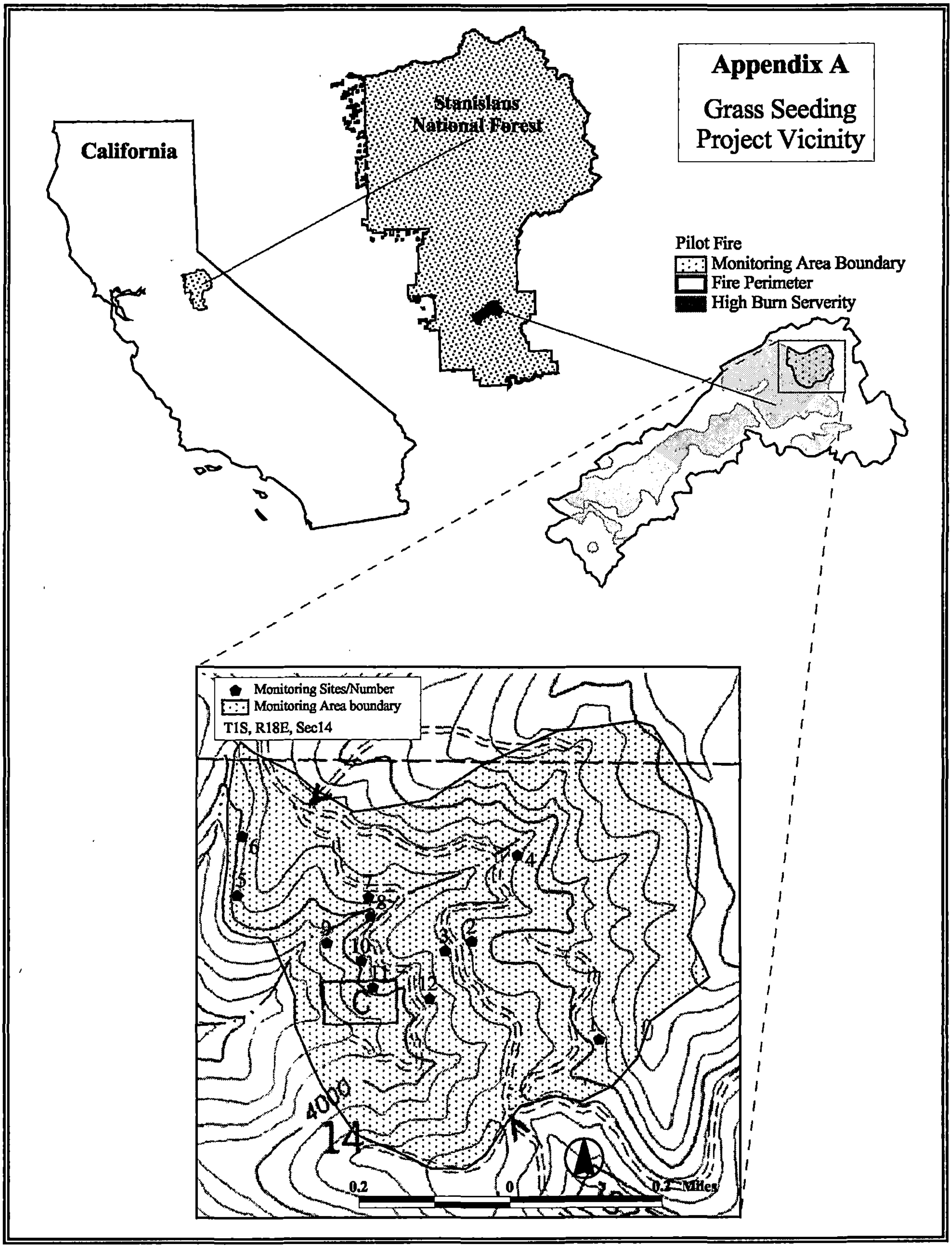
Appendix A
Grass Seeding
Project Vicinity
California
Stanislaus
National Forest
Pilot Fire
Monitoring Area Boundary
Fire Perimeter
High Burn Serverity
Monitoring Sites/Number
Monitoring Area boundary
T1S, R18E, Sec14
4000
14
0.2
0
0.2 Miles

Table 3: Grass Seeding – Monitoring Site Information

Site #	Plot #	Azimuth (deg)	Slope %	Treatment
1	1	299	35	Barley
	2	279	37	Control
2	3	262	40	Control
	4	275	37	Barley
	5	260	36	Native Mix
3	6	302	32	Control
	7[1]	258	36	Barley
	8[1]	212	31	Native Mix
4	9	303	39	Control
	10	310	32	Barley
	11[1]	313	34	Native Mix
5	12	272	44	Native Mix
	13	272	45	Control
6	14	273	51	Control
	15	288	54	Native Mix
7	16	146	26	Barley
	17	161	26	Control
8	18	320	42	Control
	19	320	40	Barley
	20	313	41	Native Mix
9	21	346	41	Control
	22	353	34	Native Mix
	23	355	28	Barley
10	24	224	36	Barley
	25	227	29	Control
11	26	231	31	Barley
	27	271	33	Control
12	28	233	35	Control
	29	219	37	Barley

[1] Disturbed Plots

Appendix B

Pilot Fire Species List
Most Common Species

Control

Lifeform	Species	Constancy[1]	Cover (%)[2]
5/00			
Trees	None		
Shrubs	Chamatatia foliolosa	75	6
	Arctostaphylos viscida	42	Tr
	Toxicodendron diversilobum	25	2
Forbs	Dichelostemma capitatum	75	1
	Claytonia parviflora	50	8
	Clarkia sp.	50	1
	Nemophila heterophylla	42	11
	Plagiobothrys humistratus	33	3
Grass	None		
5/01			
Trees	Quercus kelloggii	25	11
Shrubs	Chamabatia foliolosa	92	19
	Cercocarpus betuloides	42	11
	Ceanothus integerrimus	42	11
	Toxicodendron diversilobum	33	6
Forbs	Clarkia sp.	100	4
	Claytonia parviflora	83	3
	Dichelostema capitatum	83	1
	Nemophila heterophylla	42	2
	Galium aparine	33	1
	Lathyrus sp.	33	1
	Lotus humistratus	33	5
	Calystegia occidentalis	25	3
	Compositae (unk)	25	1
Grass	Vulpia microstachys	33	1
	Vulpia myuros	33	1

Barley

Lifeform	Species	Constancy	Cover (%)
5/00			
Trees	None		
Shrubs	Chamabatia foliolosa	60	5
	Arctostaphylos viscida	20	Tr
	Ceanothus integerrimus	20	1
	Toxicodendron diversilobum	20	3
Forbs	Claytonia parviflora	70	4
	Dichelostema capitatum	70	1
	Nemophila heterophylla	40	16
	Plagiobothrys humistratus	40	Tr
	Galium aparine	30	Tr
	Compositae (unk)	20	1
	Clarkia sp.	20	1
Grass	Elymus glaucus[3]	90	1
	Hordeum murinum[3]	90	3
	Vulpia microstachys	40	Tr
5/01			
Trees	Quercus kelloggii	20	14
Shrubs	Chamabatia foliolosa	80	20
	Cercocarpus betuloides	50	10
	Ceanothus integerrimus	40	8
	Arctostaphylos viscida	20	1
	Haplopappus sp.	20	2
	Toxicodendron diversilobum	20	6

Forbs	Clarkia sp.	100	2
	Cirsium sp.	80	1
	Compositae (unk)	80	1
	Dichelostemma capitatum	50	1
	Claytonia parviflora	40	3
	Lotus humistratus	40	1
	Nemophila heterophylla	40	4
	Galium aparine	30	1
	Plagiobothrys humistratus	30	1
	Conyza Canadensis	20	3
	Gilia capitata	20	5
Grass	Elymus glaucus[3]	70	9
	Vulpia microstachys	50	3
	Vulpia myuros	30	3
	Hordeum murinum[3]	20	1
	Poa secunda	20	2

Native

Lifeform	Species	Constancy	Cover (%)
5/00			
Trees	None		
Shrubs	Chamabatia foliolosa	57	8
	Toxicodendron diversilobum	57	2
	Ceanothus integerrimus	29	3
	Cercis occidentalis	29	5
Forbs	Dichelostema capitatum	86	Tr
	Nemophila heterophylla	71	2
	Plagiobotrys humistratus	43	Tr
	Claytonia parviflora	29	Tr
	Compositae (unk)	29	1
	Galium aparine	29	1
Grass	Deschampsia elongata[3]	100	1
	Elymus glaucus[3]	100	1
	Vulpia microstachys[3]	100	4
	Bromus carinatus	71	1
	Bromus sterilis	29	2

5/01

Trees	Quercus kelloggii	29	22
Shrubs	Chamaebatia foliolosa	71	25
	Cercocarpus betuloides	43	1
	Ceanothus integerrimus	43	7
	Toxicodendron diversilobum	43	3
Forbs	Clarkia sp.	100	1
	Dichelostema capitatum	71	1
	Cirsium sp.	57	1
	Claytonia parviflora	43	2
	Compositae (unk)	43	Tr
	Galium aparine	43	Tr
	Nemohila heterophylla	43	2
Grass	Bromus carinatus	100	7
	Vulpia microstachys[3]	100	11
	Deschampsia elongata[3]	86	3
	Elymus glaucus[3]	57	2

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[1] Constancy is the percentage of occurrence of a species in the plots. Species with less than 1 percent cover or species that occur in less than 20 percent of the plots are not shown.
[2] Cover values are the average of cover in those plots where the species occur. To obtain an estimate of the cover of a species across all of the plots in a treatment, one can multiply the cover values reported by the constancy converted to a percent. For example, if a species occurs in 50 percent of the plots and the average cover in these samples is reported as 10, the cover on all of the plots in the treatment would be 5 percent.
[3] Seeded species

Appendix C

Vegetative Response by Aspect

As noted, aspects varied in the study area. This difference was expressed in the plant communities that tended to dominate these habitats. Ponderosa pine-interior live oak dominated most of the north facing aspects while whiteleaf manzanita communities tended to dominate south aspects. Vegetation response also varied by aspect (table 4)

Table 4: Development of cover over time by aspect.

Vegetative Cover by Aspect (%)					
Aspect	Cover Class	Date Sampled			
		2/00	5/00	2/01	5/01
North	Grass	trace	4	7	11
	Shrubs/Forbs	trace	24[1]	39[1]	49
	Litter	3	4	29	45
	Bare	92	65	32	18
South	Grass	trace	4	7	10
	Shrubs/Forbs	trace	7	17	40
	Litter	1	2	9	22
	Bare	92	82[1]	67[1]	42[1]

[1] Represent variables with significant differences.

At the first midwinter reading, total vegetation was sparse on both aspects. There was essentially no difference in total vegetation cover by aspect at this time. Litter cover in the form of charcoal pieces and bark slough was higher on north aspects reflecting the higher cover of trees on these plots prior to the burn.

In the spring, both shrub and forb development was significantly higher on north aspects. Total vegetation cover was highest on north facing slopes. South facing slopes remained bare for the most part.

On north aspects bear clover and redbud were the most common shrubs while Nemophila and spring beauty dominated the forb layer. Commercial barley and small fescue were most abundant in the grass layer. South aspects were characterized by a very sparse layer of bear clover, spring beauty, short-pod lotus (*Lotus humistratus*), yerba santa

(*Eriodictyon californicum*), seeded barley, and small fescue. Grass cover for all species on either aspect contributed only 4 % of the total cover.

During the second year shrub and forb cover continued to dominate north aspects. This was reflected in significantly higher cover on north aspects, and the amount of bare ground which dominated south aspects. Litter cover remained higher on north aspects due to higher levels of vegetation cover the previous year.

Bear clover was the primary species on both aspects, but deerbrush, mountain mahogany, and poison oak (*Toxicodendron diversilobum*) were common on north aspects. The forb community on these aspects was characterized by Nemophila, spring beauty, bluedicks (*Dichelostemma cap*itatum), twining snakelily (*Dichelostemma volubile*), and Clarkia (*Clarkia spp.*). Although yerba santa had high cover on a few plots, mountain mahogany was the only shrub other than bear clover that was common on south aspects. Spring beauty, short-pod lotus, thistle (*Cirsium spp.*), and Clarkia comprised most of the forb cover on south aspects. Barley had disappeared from all plots and the relatively sparse grass cover on either aspect was dominated by *Brous carinatus* and *Vulpia microstachys* from the seed mixes. Seeded *Elymus glaucus* was common on north aspects and rattail fescue was a somewhat common grass on south aspects.